Electronic Services - Hayward, Ca
M17207X

# OPERATING AND SERVICE MANUAL

# 120C
# STRAIN
# INDICATOR

RETURN TO:
TECH. & DEV. INST. LAB.
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BLH

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## *Section 1*
# GENERAL INFORMATION

### 1.1 General

The BLH Portable Model 120C Strain Indicator is used for field and laboratory measurements of strain in structures and machines by indicating the change of electrical resistance in strain gages.

This instrument, Figure 1-1, has been designed and calibrated especially to work with resistance strain gages having an initial resistance of 120 ohms and a gage factor of any value from 1.5 to 4.5. Gages with initial resistance of 60 to 2000 ohms can be used with equal ease and accuracy.

The Model 120C Indicator uses a manually operated null-balance system with digital readout for fast accurate reading. The indicator has a total range of 0- ±30,000 microinches per inch, covered by 12 intervals of 5000 microinches per inch each.

### 1.2 Description

The Model 120C Strain Indicator is a portable, AC or battery operated unit providing many important features. Digital readout permits quick, accurate reading without potential parallax and interpolation errors. Completely transistorized, extra-rugged circuitry provides dependable service under field conditions.

Circuitry of the indicator includes an 1100 cps transistorized amplifier, phase-sensitive detector, counter, null meter, and measuring circuit. See theory of operation, Section 3 for complete circuit details.

### 1.3 Applications

The Model 120C Strain Indicator measures the change in electrical resistance of strain gages and through a manual null-balance digital readout system transforms this change into a reading in microinches per inch strain.

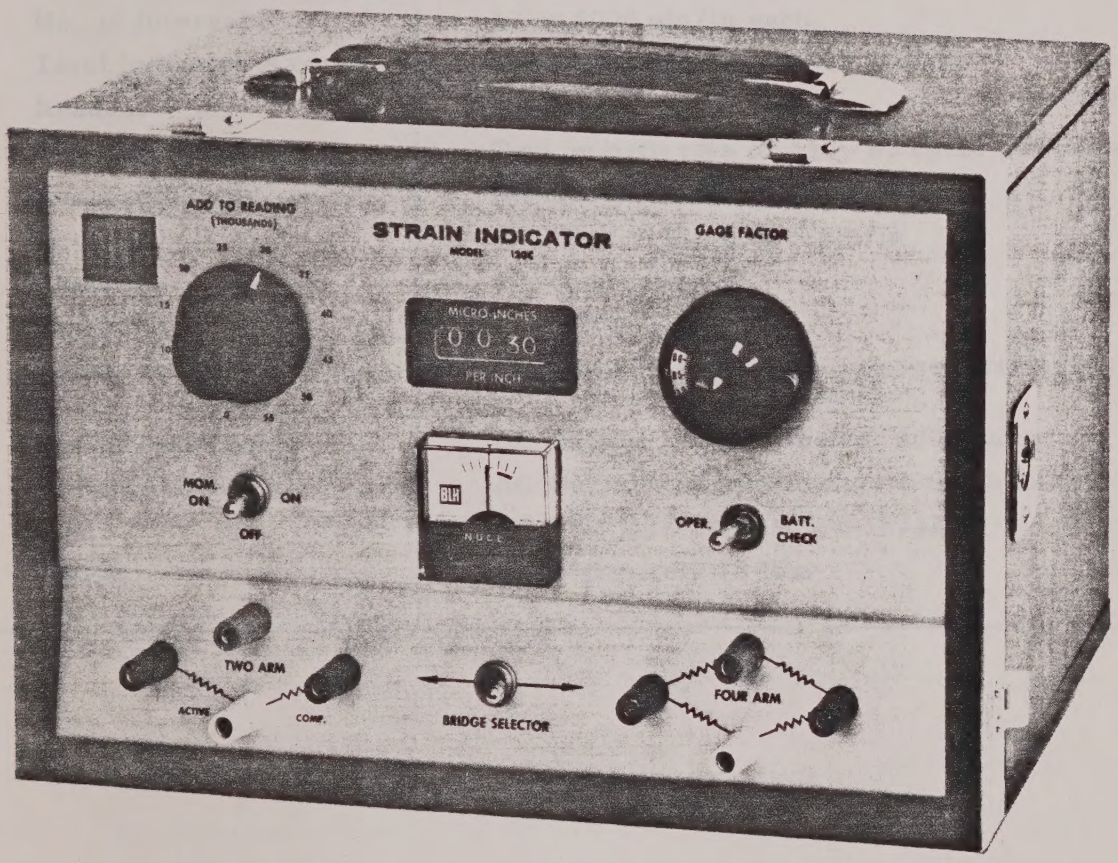



Figure 1-1. Model 120C Strain Indicator

| | |
|---|---|
| Input | 1, 2 or 4 arm strain gage networks. |
| Gage Resistance | 60 to 2000 ohm gages. |
| Gage Factor Range | 1.5 to 4.5 |
| Counter Range | 5000 μin. |
| No. of Intervals | 12 at 5000 μin/in each. |
| Total Indicator Range | ±30,000 μin/in or 60,000 μin/in |
| Readout | Digital. |
| Power Requirements | Two 6v batteries or 115v 60 cycle power pack. |
| Response speed | Manual Null balance. |
| Accuracy | ±0.1% of reading or 5 μin/in |
| Linearity | ±0.1% of interval |
| Sensitivity | Less than 2 μin/in |
| Dynamic Range | ±5000 μin/in ≅ ±0.1V at a gage factor of 2, 0-50 cps at the scope jack. |
| Output Impedance | DC Output: Approximately 3000 ohms |
| At Scope Jack | AC Output: Approximately 2000 ohms |
| Size | 9 1/2"H x 12 29/32W x 8 13/32D |
| Weight | Approximately 18 lbs. |

## *Section 2*
# OPERATION

### 2.1 General

This section provides information covering unpacking, packing, inspection after shipment, initial application of power and general operation. Please read the paragraphs on General Operation before energizing the Indicator.

### 2.2 Unpacking Instructions

There are no special instructions required; simply use standard unpacking procedures.

### 2.3 Packing for Shipment

If you return the Indicator to Baldwin-Lima-Hamilton during the equipment warranty period, be sure to follow these instructions carefully to avoid transportation damage which might NOT be included in the warranty. Contact Baldwin-Lima-Hamilton or your nearest authorized BLH Representative. Explain the difficulty so that BLH or an authorized Representative may determine the return procedure which will provide the quickest service for you. Generally, the local authorized BLH Representative can remedy the problem without removing the equipment from your Plant. In the rare case where it becomes necessary to actually ship the faulty unit, please follow the remaining steps. Baldwin-Lima-Hamilton will rush you instructions as to speedy shipment and insurance requirements. DO NOT SHIP EQUIPMENT UNTIL THESE INSTRUCTIONS HAVE BEEN RECEIVED BY YOU.

1. Carefully inspect the Indicator for loose items. Secure any loose components.
2. Obtain a shipping container which is sufficiently large to permit one inch of shock absorbing padding to surround the unit. Suitable padding materials are:
   a. Shredded newspaper
   b. Crumpled newspaper
   c. "Kimpak"
   d. Excelsior, either wood or paper
   e. "Rubber Hair"
3. Prior to putting the Indicator in the inner container, wrap the unit in paper or place it in a bag to prevent damage during shipment.
4. Place the inner container in a larger box, surrounding the inner box with at least 1 inch (top, bottom and sides) of the same isolating material.

5. Address the box. Containers of 2 cubic feet or more should have address labels on at least two opposite sides.

6. Be sure to insure the shipment according to instructions sent by Baldwin-Lima-Hamilton.

7. The method of shipment depends on the costs involved and the urgency of the shipment.

## 2.4 Inspection After Shipment

Reasonable care has been taken to pack the Indicator in such a manner that it will reach its destination in perfect condition. However, to be sure that the instrument will function properly, check to see that it has not been damaged. There should be no dents, cracks, or breaks in the case.

## 2.5 Installation

### 2.5.1 Initial Installation

The selection of a suitable location for the Indicator is important for satisfactory operation. The ideal location is a clean, dry room with uniform temperature. Locations where the Kit will be subjected to temperatures above 110°F or below 32°F should be avoided.

A ten-foot power cable is included with the Indicator when an AC power supply is used. One end of the cable is connected to the 115 VAC connector located on the lower right side of the Indicator; the other end of the cable is connected to a source of 115-volts, 60 cps power.

### 2.5.2 Connection to Instrument

Two arm bridge configurations are connected to the left hand group of color coded terminals as shown by the engraving on that group of terminals. The four arm gage configuration (full bridge) are connected to the right hand group of color coded terminals. The BRIDGE SELECTOR switch is then positioned toward the group of terminals in use.

### 2.5.3 Wiring

It is advisable to select lead materials which have low, stable resistivity, minimum temperature coefficient of resistance, coated with insulating materials which are equivalent to the electrical insulating quality of the gage carrier and bonding cements employed. The following materials have been found suitable for BLH strain gage use. For other than BLH strain gages consult the manufacturer.

| Conductors | Operating Temperatures °F | |
|---|---|---|
| | Stable | Maximum |
| Nickel-clad copper | 700 | 1000 |
| Stainless steel-clad copper | 800 | 1300 |
| Nickel-clad silver | 1000 | 1500 |
| Nichrome | 700 | 1700 |

| Insulation | Temperature Range |
|---|---|
| Nylon | Below -100°F |
| Vinyl | -100 to 150°F |
| Polyethylene | -100 to 200°F |
| Teflon | -100 to 500°F |
| Glass impregnated silicone | above 500°F |
| Glass sleeving | above 500°F |

It is preferable to solder connections to the gage lead wires. Clean, tinned spade type lugs soldered to the lead wires are preferable for connections to the binding posts of the instrument. Stranded wire, if used, should have all strands intact and special care should be taken to see that all strands are soldered.

In locations where the strain Indicator is being operated in the vicinity of strong electrical disturbances, it may be necessary to use shielded cable for the leads to the active and compensating gages when these lead lengths are long. The shield of this cable should be grounded at only one point.

2.5.4 Installing Batteries

Remove Indicator from case by removing two screws on bottom side. Install batteries as follows:

a. Use two type F4BP batteries, each 6 volts. Place plastic bags over batteries for protection.

b. Secure battery support and batteries in place with two screws.

c. Use a black lead to connect the negative terminal of one battery (#1) to the positive terminal of the other battery (#2).

d. Connect a green lead from the negative terminal of battery #2 to terminal "G" on the barrier strip.

e. Connect a red lead from the positive terminal of battery #1 to terminal "R" on the barrier strip.

f. Replace Indicator in case and secure with two screws through bottom side.

2.5.5 Installing AC Power Supply

Remove Indicator from case by removing two screws on bottom side. Install power supply as follows:

a. Remove screws from flanges of power supply.

b. Mount power supply in place; insert screws through the bottom of instrument bracket into power supply mounting flanges.

c. Connect power supply cable to barrier strip as follows:

Black lead connects to "B" Terminal (115 VAC in)
White lead connects to "W" Terminal (115 VAC in)
Yellow lead connects to "Y" Terminal (GND)
Green lead connects to "G" Terminal (-12 volts)
Red lead connects to "R" Terminal (+12 volts)

d. Replace Indicator in case.

2.6 Power Requirements

The Indicator operates with either two 6-volt batteries or an optional 115 VAC 60-cycle power supply.

2.7 Description of Controls

A listing of the front panel controls and their functions is provided below. Before energizing the Indicator, the operator should become familiar with these controls and the operating instructions below.
NOTE: CAPITAL LETTERS indicate the exact front panel markings. See Figure 2-1.

ADD TO READING

This switch is graduated from 0 to 55 and shifts the reference point of the counter by 5000 microinches per inch for each step of the switch. The position of the ADD TO READING Switch corresponding to 30,000 microinches per inch (30, switch marking) is the zero of the Indicator. This allows for ±30,000 microinches per inch of operation.

DIGITAL COUNTER

This digital counter, in conjunction with the Add-to-Reading Switch, is used to indicate the magnitude of the load. When the meter is balanced, this digital counter reading is added to the Add-to-Reading Switch setting.

NULL METER

This meter is used to indicate a balance between the strain gage bridge output voltage and the measuring circuit voltage. When the Balancing control is rotated, the meter can

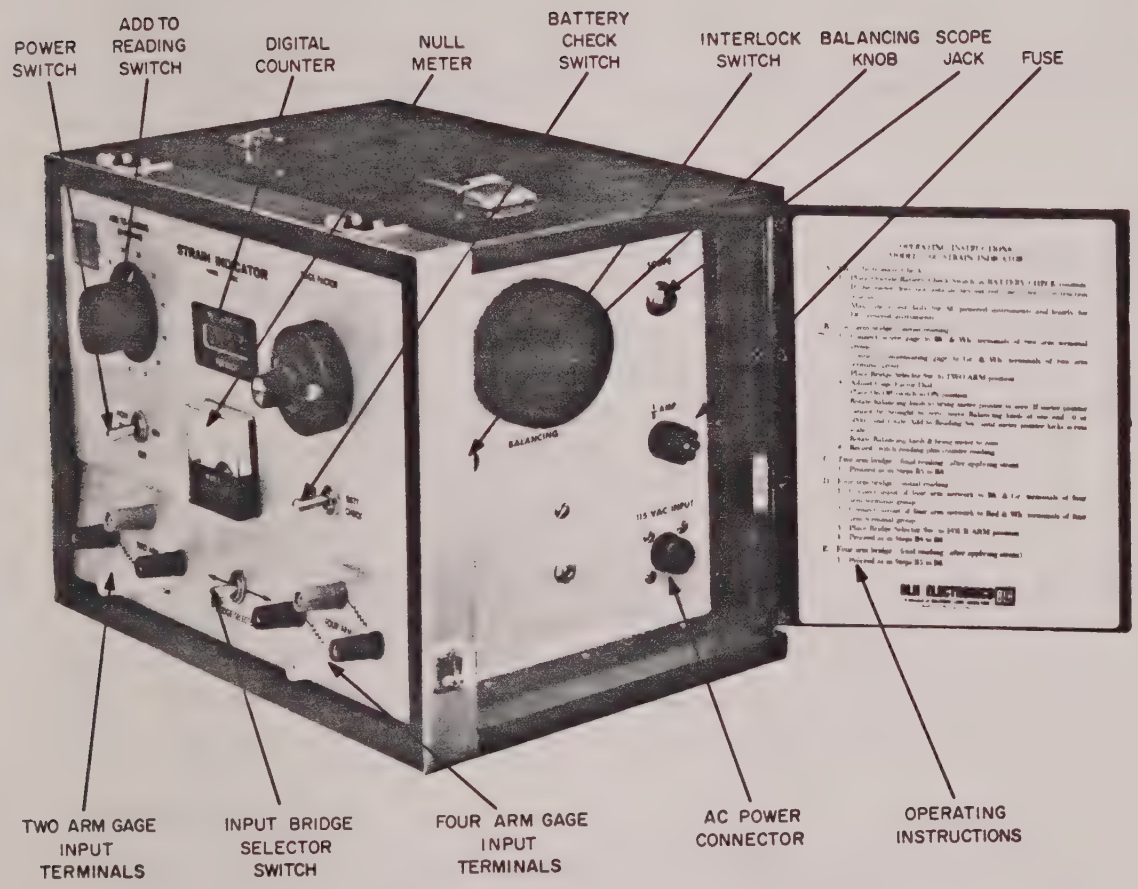
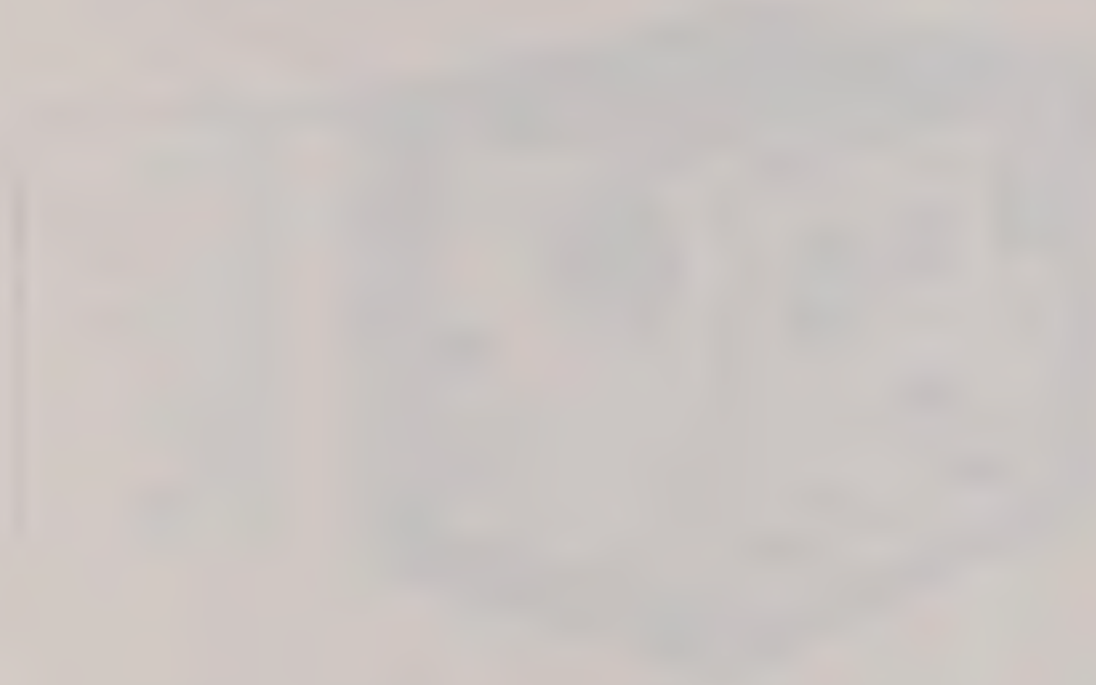



Figure 2-1. Model 120C Operating Controls



be nulled (pointer at 0) if the strain gage bridge output voltage equals the measuring circuit voltage.

GAGE FACTOR

The gage factor potentiometer is graduated from 1.5 to 4.5, and, when set to the factor corresponding to that on the gage in use, applies the proper voltage to the measuring circuit for that gage.

BRIDGE SELECTOR

Two sets of color coded terminal connections are mounted on the lower left and right side of the front panel. The left hand group is marked for two arm bridges and the right hand group for a four arm bridge configuration. The BRIDGE SELECTOR toggle switch located between the terminal groups selects the bridge configuration to use by positioning the switch in the direction of the terminal group used. The two arm bridge contains an internal half bridge of 500 ohms to complete the bridge for that grouping.

BATT. CHECK/OPER.

The BATTERY CHECK/OPERATE switch is used to check the battery voltage. When held in the BATTERY CHECK position the METER needle should deflect to the right and past the red area. If the meter needle remains in the red area the battery is weak and should be replaced. For normal operation the switch is maintained in the OPERATE position. This switch can also be used to check the AC Power Supply, when provided.

MOM. ON/OFF/ON

This switch controls the power to the Indicator. Should the operator desire to take but a single occasional reading the power switch has a MOMENTARY ON position. The switch must be held in this position while taking the reading and will return to off when released. This will extend the life of the batteries.

BATTERY INTERLOCK

This control, located on the right side panel, deactivates the power to the instrument when the side door is closed. This switch prevents battery discharge should the POWER switch accidently be left ON when the instrument is closed up for storage.

BALANCING

This control is located on the right-hand side panel and is geared to the slidewire and counter. When this control is rotated it provides a balance between the strain gage output voltage and the measuring circuit output voltage. When the exact balance occurs, the Null meter should indicate 0.

1/8 AMP/FUSE

This is the input power fuse.

115 VAC INPUT

When the Indicator is equipped with an AC Power Supply, the mating plug at the end of the input power cable is inserted into this connector. The AC power supply is protected with an independent 1/8 amp fuse located on the power supply chassis.

SCOPE

The scope jack on the right side panel is used for connecting to any standard oscilloscope for observation of dynamic strains.

## 2.8 Operation

### 2.8.1 Preliminary adjustments.

For best results, calibrate the Indicator using the procedure in Paragraph 2.9 before each series of measurements. To operate the Indicator, remove the top cover, open the right side door and perform the following steps:

1. Connect Strain gages to input terminals.
2. Turn MOM. ON/OFF/ON (power switch) to ON.
3. Turn BATT CHECK/OPER switch to BATT. CHECK position. The Null meter pointer should move to the right. If the pointer stops in the red area, the batteries should be replaced (if a battery power supply is used) or the AC power supply should be check (if an AC power supply is used). Repeat check hourly if the indicator is used continuously. To conserve batteries, always turn power off when not taking readings.

4. Set the GAGE FACTOR dial in upper right corner to exactly the value listed on the container in which the strain gages are received, or the value marked on the gage itself, and make a record of this setting. In order to be able to reproduce strain readings at some later date, it is essential that the gage factor dial be set precisely at the same value as before.

5. It may be desirable at times to determine the true indicator zero in order to eliminate errors arising from slow changes of instrument zero which may be due to temperature, battery voltage drop, etc. To do this, it is necessary to take readings on two resistors or gages preferable within about 1/10% of each other, first in one position and then with the two resistors or gages reversed. The

average of the two dial readings gives what is called the "indicator zero," which is used to correct all strain readings to the same basis. By this method precision measurements can be made during long-time tests. Also, measurements can be taken on the same gages with different indicators without loss of accuracy.

6. To make measurements on materials such as plastics and metals in the plastic region, or to increase the range of the dial so that strain readings can be made without resorting to a change of the "ADD TO READING" switch, it is only necessary to introduce fixed wire-wound resistors in the gage circuits as shown in Fig. 2-2. By the use of formulas shown in Fig. 2-2, the dial range can be increased appreciably. The resistors should all be precision, non-inductive wire-wound type accurate within ±0.25%. The formulas hold closely for values of M up to M = 10.

### 2.8.2 Strain Measurement

The strain in the specimen is the difference between the initial and the final instrument readings made up of the dial readings as well as the ADD TO READING switch readings.

1. Initial reading is obtained as follows (before applying strain):
   a. Place ADD TO READING switch on 30.
   b. ROTATE BALANCING knob in direction to bring meter pointer to zero. If meter pointer cannot be brought to zero, leave COUNTER AT END TO WHICH IT HAS BEEN TURNED (0 to 5000).
   c. Rotate ADD TO READING switch until meter pointer kicks across scale.
   d. Rotate BALANCING knob to bring meter pointer to zero.
   e. Record COUNTER and ADD TO SWITCH readings.
2. Final READING (after applying strain)
   a. Proceed as in 1-b to d above.
   b. Record all COUNTER and ADD to READING switch readings with meter pointer at zero and strain applied.
3. Computation of strain.

   Instrument readings as indicated in 1-e and 2-b in preceding paragraph give both the magnitude of the strain and information as to whether the specimen is under tension or compression.

   $(T_2 - T_1)\ 1000 + D_2 - D_1$

   $T_2$ — Final ADD TO READING switch position.

$T_1$ — Initial ADD TO READING switch position.

$D_2$ — Final Counter reading.

$D_1$ — Initial Counter reading.

The sign of the strain given by the formula will indicate whether the strain is tension or compression. Positive sign corresponds to tension in measuring gage.

2.8.3 Measurements with Strain Gages of Resistance other than 120 Ohms.

This instrument can be used in connection with any resistance wire strain gage having an initial resistance between 60 and 2000 ohms. The active and compensating gages preferably should have their initial resistances equal with 1/2%. The wiring and installation of these gages and the operation of the instrument is the same as for standard 120 ohm gages.

2.8.4 Effect of Lead Wire Resistance.

While for most measurements the effect of lead wire resistance is negligible, it may be of importance where long leads or small-size leads are involved and high accuracy is required.

The presence of lead wire resistance in series with a strain gage reduces the effective gage factor in proportion to the ratio of the lead resistance to the gage resistance. This may be taken into account either by applying corrections to the indicated strains or by reducing the gage factor setting.

For example, suppose there is an active 120 ohm strain gage 50 ft. from the instrument, the lead wires being #18 gage copper (6 ohms per 1000 ft.), while the compensating gage is at, or close to, the instrument. The total lead wire resistance (100 ft.) of 0.6 ohm causes a reduction in the effective gage factor of 0.6/120, or 0.5%. Therefore, if the gage factor dial is set at the true gage factor (as found on the gage package) the indicated strains will be 0.5% low. If the gage factor dial is set as 99.5% of the true gage factor, the instrument will automatically compensate for the lead wire resistance effect. If the lead wire resistance exceeds about 5% of the gage resistance, a more exact calculation is required. However, if the active and compensating gages are at the same location, the effective gage factor reduction will be one-half of that computed above, and may be compensated for in the same manner.

2.8.5 Visual Indication of Dynamic Strain.

Although the Model 120C indicator is designed as a null-balancing instrument for the measurement of static strains, the provision of a "Scope Jack" in its side panel permits the convenient and practical observation of dynamic strains with the aid of any standard

cathode-ray oscilloscope. If the magnitude of the strain to be observed is below about 5000 microinches per inch, for a gage factor of 2.0, the indication is quantitative. Beyond that, the strain indicator amplifier becomes non-linear, but by using the circuit of Figure 2-2, proportionately larger dynamic strains can be observed with good linearity. The procedure is as follows:

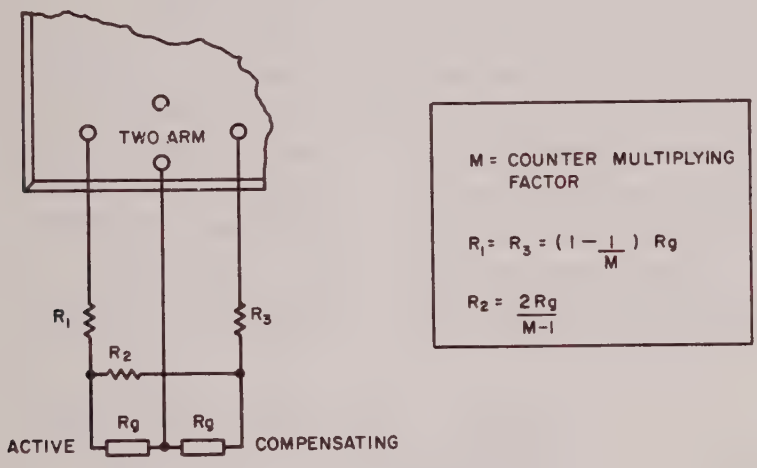



Figure 2-2. Increasing range of digital counter.

1. Set the gain of the oscilloscope so that a signal of approximately 0.1 volt will occupy most of the screen. This is about the magnitude of the signal resulting from a 5000 microinch per inch unbalance.
2. Make the proper connections between the oscilloscope and the Scope Jack Plug. A two conductor plug, Switchcraft #40 or its equivalent, should be connected as follows:

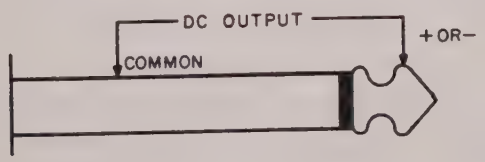



Figure 2-3. Scope Plug

2.8.6 Use with External Bridge Circuit.

In certain strain gage investigations it is advantageous to connect the gages into a closed external bridge circuit which is connected to the Strain Indicator by four lead wires (usually a 4-wire shielded cable) to the right hand group of terminals. The effect of variations in cable and terminal contact resistance upon the strain measurements, are then minimized because both sources of error are external to the gage bridge.

The external bridge also lends itself to realization of increased measuring sensitivity in cases where it is practical to employ two active and two compensating gages (connected alternately around the bridge loop). The indicated strain will then be just twice the actual strain since the two active gages will produce an additive effect in unbalancing the bridge. This arrangement has been used effectively where the strains to be measured are very small. To use the Model 120C Strain Indicator with an external 2 active arm bridge circuit connect the bridge to the right hand group of terminals as follows:

1. Connect the power input terminals of the external bridge to the Black and Green binding posts.
2. Connect one bridge output terminal to White binding post.
3. Connect the other output terminal to Red binding post.
4. Throw the 2-arm 4-arm switch to 4-arm.
5. Set the gage factor dial to the value of the gages in use.
6. Read the instrument and calculate indicated strain as in 2.8. Divide by 2 for true strain.

NOTE: The Model 120C Strain Indicator can be used to measure the response of any of the BLH line of standard BLH transducers (such as load and pressure cells) all of which are bridge circuits adjusted to standard output and fully compensated for temperature. For this service, set the gage factor dial for the particular transducer in use. Measure the "apparent strain" in microinches per inch in the manner outlined above and divide by the number 2000. The result is the true pickup output expressed in terms of millivolts output per volt input.

For example, given a standard 5000 lb. capacity BLH Type "C" load cell which has a terminal resistance of 120 ohms. From the load cell data sheet, we find that the gage factor dial must be set at 2. The output of the cell is factory adjusted to 2.00 mv/v at 5000 lbs., so it is evident that capacity load will produce an apparent strain reading of 2 x 2000 microinches per inch. In other words, the true load is $\frac{S \times 5000}{2 \times 2000}$ where S is the apparent strain.

The effect of lead wire resistance in the case of an external bridge circuit may need to be considered in some instances. As to lead wire resistance inside the bridge loop, the

presence of lead wire resistance in the arm of the bridge reduces the effective gage factor of the strain gage in that arm in proportion to the ratio of the lead resistance to the gage resistance. Lead wire resistance external to the bridge loop is of no consequence at all if it is in series with the output terminals of the bridge since at most it amounts to a few ohms in a high impedance circuit.

Any lead wire resistance in series with the power input terminals of the bridge will reduce the effective output of the bridge in proportion to the ratio of the lead resistance to the bridge resistance as measured across the power input terminals. Correction can be effected in the same manner as explained in the example in paragraph 2.8.4.

## 2.9 Calibration

We have 250 calibrator

2.9.1 The Strain Indicator measuring circuits are constructed of highly stable fixed and variable wire wound resistors and should give long service without recalibration. If a component in the measuring circuit should fail and necessitate a replacement or if for other reasons the accuracy of the Indicator is in doubt, a check of the calibration can be made by the use of the BLH Model 625 Calibrator.

2.9.2 To check the calibration of the Model 120C Indicator using the Model 625 Calibrator proceed as follows:

1. Connect the left hand group of the Calibrator's color coded terminals, color for color to the right hand group of color coded terminals of the Strain Indicator.

2. Position controls on Calibrator as follows:

   BRIDGE SELECTOR SWITCH — 120 ohms
   RANGE SWITCH — 0-10
   STEP SWITCH — 0

3. Position controls on Model 120C Indicator as follows:

   BRIDGE SELECTOR SWITCH — FULL BRIDGE
   GAGE FACTOR — 2.000 (Note: Must be set exactly)
   ADD-TO-READING SWITCH — 30
   POWER SWITCH — ON

4. Prior to operation check Battery or D.C. Power of Strain Indicator by placing OPER-BATT-CHECK switch to BATT. CHECK.

5. Zero the Strain Indicator as in Paragraph 2.8.2 1-a to 1-e and record reading.

6. Set STEP switch of the Calibrator to 1 mv/v.

7. Balance the Strain Indicator as in Paragraph 2.8.2, 1-b to 1-e above and record reading.

8. Set the STEP switch of the Calibrator to 2 mv/v, 3 mv/v, in 1 mv/v steps through 10 mv/v, pausing at each setting to balance the Strain Indicator and record the reading.

9. A series of readings from 0 to 20,000 microinches per inch in 2000 microinches per inch steps for each 1 mv/v reading should be obtained. Compute each value as in Paragraph 2.8.2, 3.

10. Readings in the opposite direction are obtained in the same manner but first reverse the Black and Green leads at the Calibrator.

2.9.3 Readings of this calibration check should be ±50 microinches per inch at ±20,000 microinches per inch. Should this check of the calibration reveal errors of more than ±50 per inch, but less than ±100 microinches per inch, this error may be corrected by adjusting the GAGE FACTOR control as follows:

1. Remove knob from the GAGE FACTOR control by loosening the set screw.

2. After knob is removed, another set screw can be seen on the shaft of the GAGE FACTOR counter assembly. Loosen this set screw and remove the counter assembly.

3. After counter assembly has been removed and with 20,000 microinches per inch applied, rotate the shaft of the GAGE FACTOR control so that the Strain Indicator reading is 20,000 microinches per inch ±20 microinches per inch.

4. Install counter assembly being sure that the GAGE FACTOR control is set on exactly 2.000.

5. Replace GAGE FACTOR knob.

NOTE: This procedure is recommended only for minor adjustments. If major adjustment is required, it is recommended that the Strain Indicator be returned to BLH Electronics, Waltham, Mass. for recalibration.

## *Section 3*
# THEORY OF OPERATION

### 3.1 General

The Strain gage bridge produces an output voltage proportional to the load applied. The indicator measures the voltage and translates this voltage into an indication in units corresponding to the Strain. See Block Diagram, Figure 3-1.

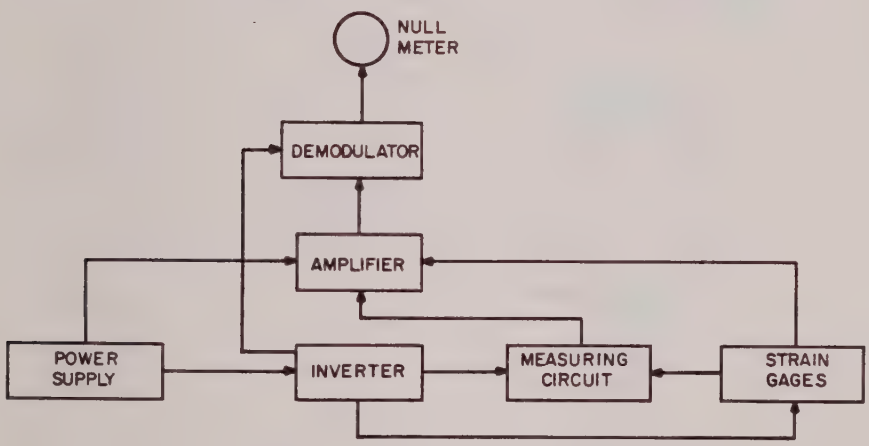



Figure 3-1. Block Diagram

### 3.2 Indicator Panel

The Indicator includes a 1100 cps transistorized 12 volt DC-AC inverter, a transistorized amplifier, a demodulator, a null-balance meter, a measuring circuit and a power supply.

#### 3.2.1 Measuring Circuit (See Figure 3-2)

The Indicator uses a measuring circuit (null balance principle) consisting of a resistance balancing network and an electronic amplifier. The Strain gage bridge is electrically connected to this measuring circuit. The amplifier operates from the measuring circuit to drive the meter to a position determined by a slidewire coupled to the Balancing Control. Any difference in voltage output between the instrument and the Strain gage bridge is amplified and sent to the NULL meter. Operating the Balancing Control

moves the brush on the slidewire until the measuring circuit output equals the load cell output; at this point, the meter nulls (pointer at 0). Since the NULL meter operates in conjunction with the Balancing control, its final position will be related to the position of the slidewire brush and, therefore, to the output of the Strain gage bridge.

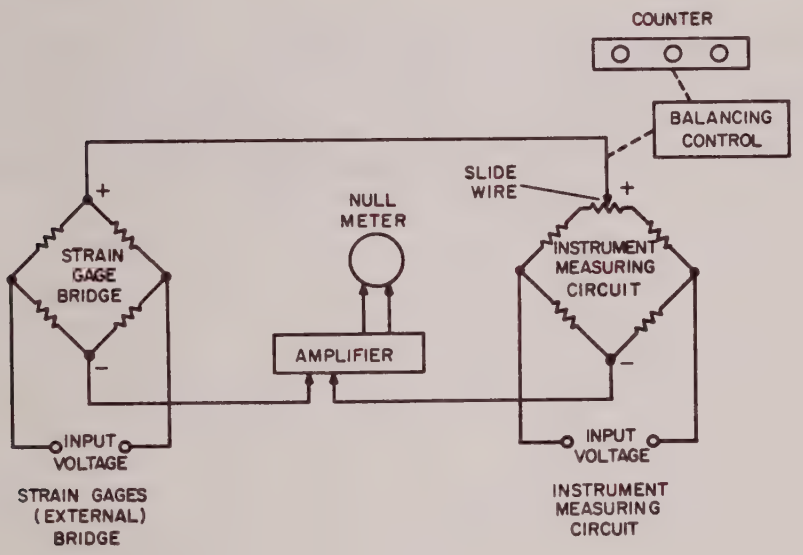



Figure 3-2. Null-Balance, Functional Diagram

### 3.2.2 Power Supply

The power supply provides a 12 VDC supply to the inverter pins 3 and 4, and also to amplifier + and - terminals.

### 3.2.3 Inverter

The DC-AC inverter, energized by the 12 volt DC supply, provides an AC output in the form of a square wave with a frequency of approximately 1100 cps. Three separate voltages are obtained from the output transformer. These are the 3 volt, 3 volt, and 1 volt outputs. A 3 volt winding supplies the measuring circuit voltage; a 3 volt winding excites the Strain gage bridge; and the 1 volt winding is the reference supply for the demodulator on the amplifier circuit board.

### 3.2.4 Amplifier

The amplifier provides a single ended input to the phase splitter Q1. This signal is amplified through two differential R-C coupled amplifier stages. R10 (a balancing potentiometer) balances the output of Q2 and Q3. The output of Q4 and Q5 is applied to the primary of transformer T1.

### 3.2.5 Demodulator

The amplified signal from the amplifier passes to the demodulator. The demodulator produces a DC voltage to deflect the NULL meter. The polarity and magnitude of this voltage is dependent upon the phase and magnitude of the difference between the Strain gage bridge and measuring bridge voltages.

## *Section 4*
# MAINTENANCE

### 4.1 General

Periodic inspection or maintenance is not necessary. The transistors, capacitors and resistors are operated well within their peak ratings and should give long, trouble-free operation.

### 4.2 Troubleshooting

During troubleshooting, refer to the Indicator Schematic Diagram. To isolate the trouble to the Indicator or the Strain gage, proceed as follows:

1. Perform calibration procedures per instructions in Paragraph 2.9 of this Manual.
2. If calibration results are normal, then the trouble is in the strain gage bridge.
3. If calibration results are abnormal, then the trouble is in the Indicator.

#### 4.2.2 Indicator (See Figure 4-1)

Malfunctions in the Indicator should be localized in the following order:

1. Check power supply
2. Check 12-volt DC-AC Inverter
3. Check amplifier
4. Check measuring circuit
   a. Measuring Board
   b. ADD-TO-READING Switch

If the Indicator is defective and internal troubleshooting is necessary, it should be performed by a qualified electronic technician with the following equipment available for his use:

Multimeter, Simpson Model 260 or equal
Oscilloscope, Tektronix, with a high gain differential preamplifier, or equal
Audio Oscillator, Hewlett-Packard Model 204B, or equal.

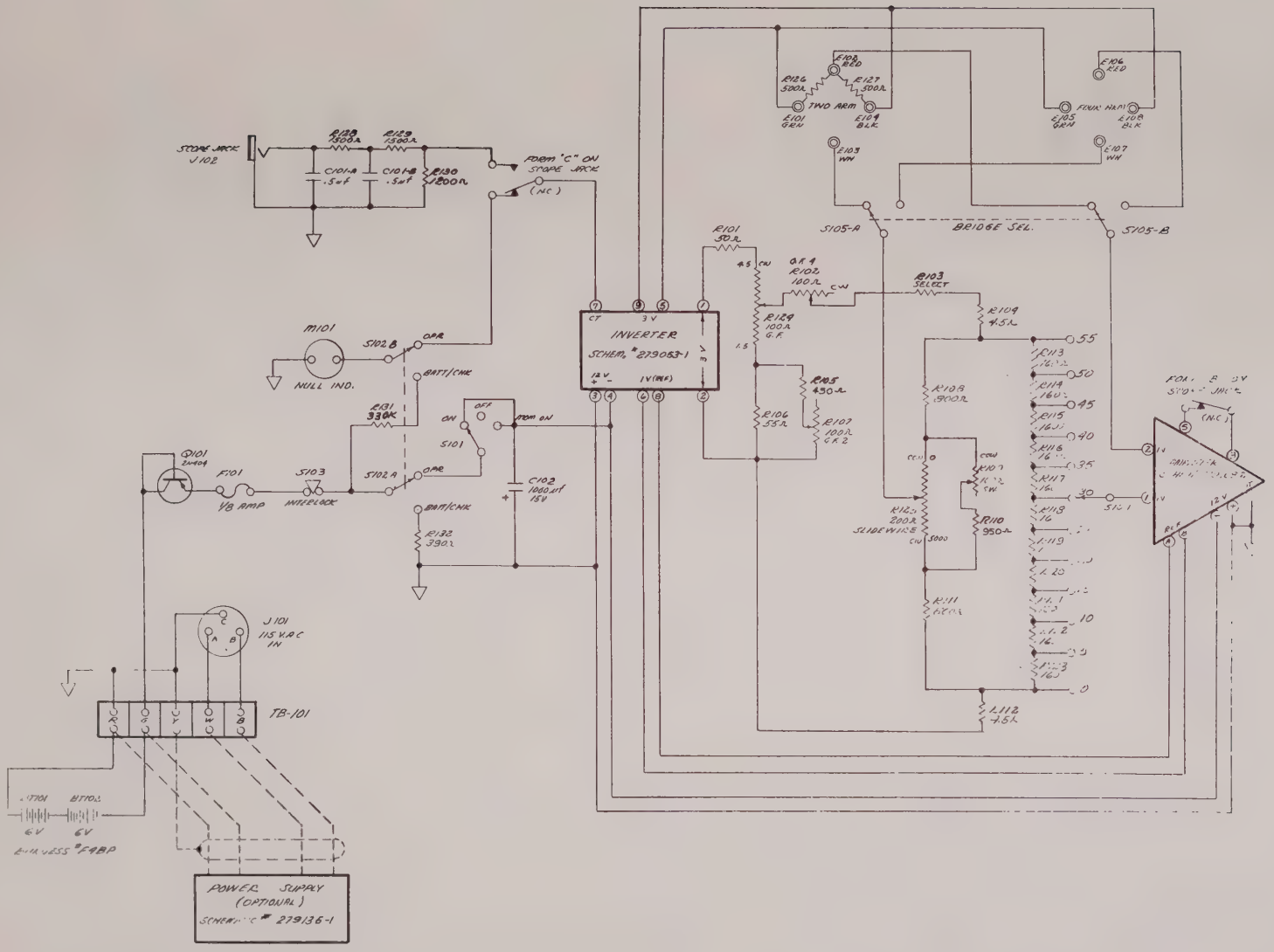



Fig. 4-1. Model 120C - Schematic Diagram

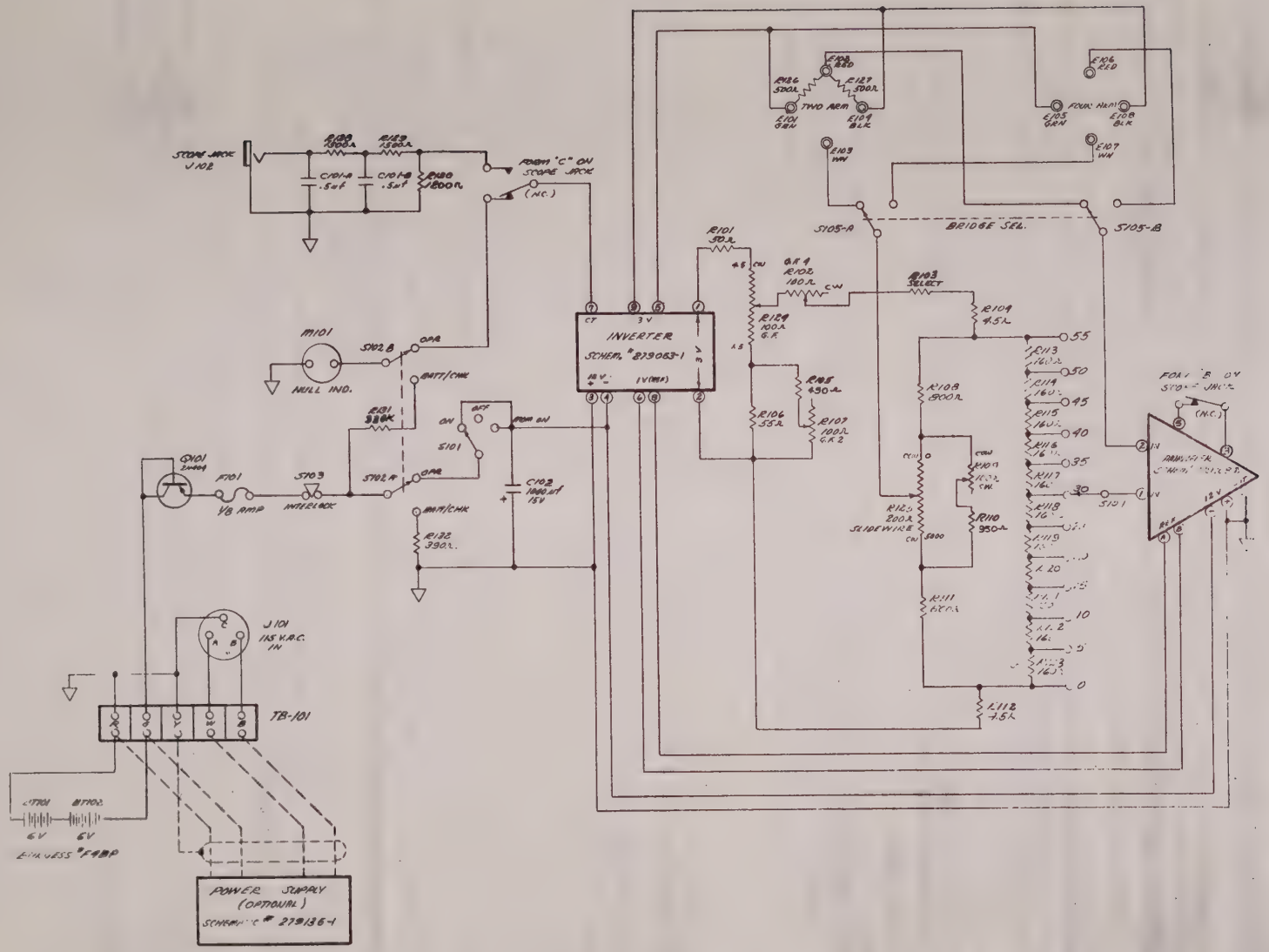



Fig. 4-1. Model 120C - Schematic Diagram

4.2.2.1 Power Supply (See Figure 4-2)

Check the power supply as outlined below:

1. Turn BATT. CHECK/OPER switch to BATT. CHECK position. The NULL meter pointer should move to the right.
2. If the pointer in Step "1" is in the red area of the meter and batteries are being used, change the batteries.
3. If the pointer in Step "1" is in the red area of the meter and the AC power supply is being used, use a DC voltmeter to check the voltage across terminals "G" (-) and "R" (+) of the barrier strip. The voltage should be 12 volts.
4. If the voltage in Step "3" reads zero, use an AC voltmeter to check the voltage across terminals "B" and "W" of the barrier strip. The voltage should be 115 VAC.
5. If the voltage in Step "4" reads 115 VAC, the AC power supply is faulty and should be replaced. If the voltage is not 115 VAC, check the power source, power input cable, POWER switch, and power wiring to the power supply.

Recalibrate per Paragraph 2.9.

4.2.2.2 12-Volt DC-AC Inverter (See Figure 4-3)

This encapsulated unit may be checked without disconnecting it from the circuit or removing it from the instrument, using the method below:

1. Turn off the instrument.
2. Disconnect the strain gage bridge.
3. Add a 120 ohm, 1/2 watt ± 10% resistor across pins 5 and 9 on the inverter.
4. Measure the wave shape across this resistor with the oscilloscope. The wave shape should be approximately 6 volts peak-to-peak square wave with a frequency of 1100 cps ± 10%.
5. Check the demodulator reference voltage by placing the oscilloscope across pins 6 and 8 of the inverter. This voltage should read about 2 volts peak-to-peak.

If the above voltage readings are not obtained and the 12-volt power supply is satisfactory, the inverter must be replaced since it is an encapsulated unit and is non-repairable. When the new inverter is installed, the Indicator must be recalibrated, per Paragraph 2.9.

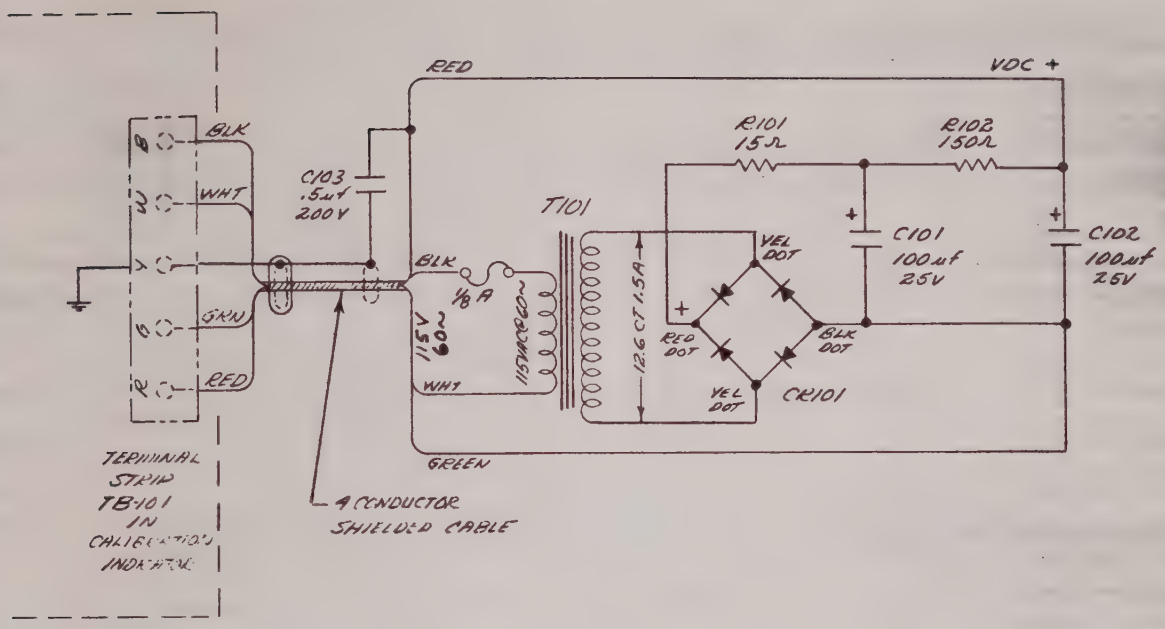



Fig. 4-2. Power Supply - Schematic Diagram

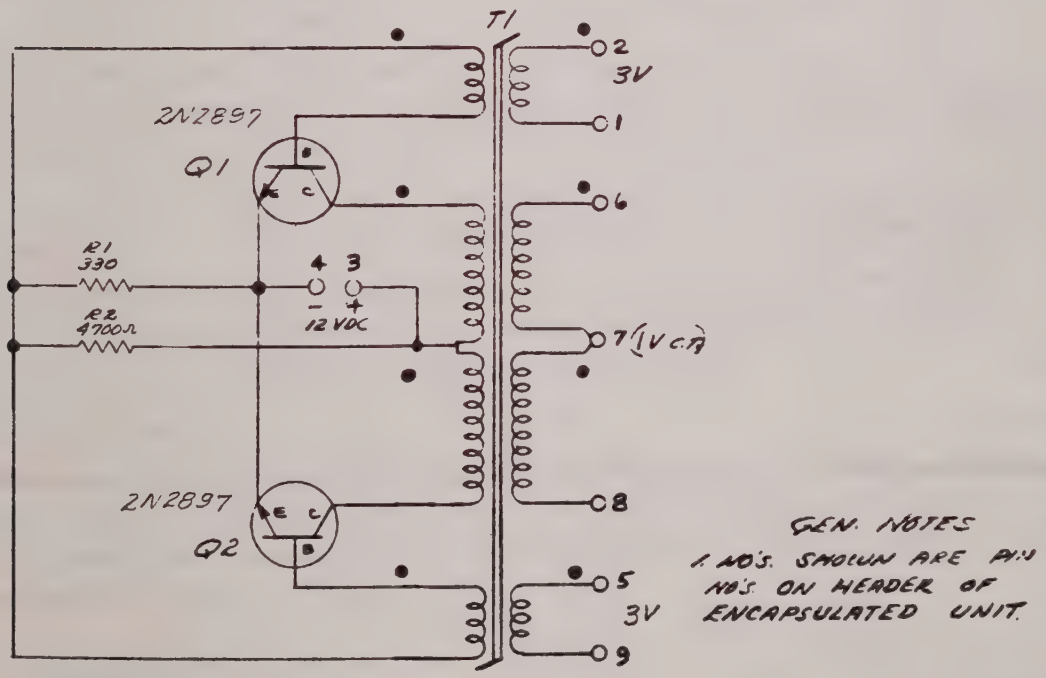



Fig. 4-3. 12 Volt DC-AC Inverter - Schematic Diagram

4.2.2.3 Amplifier (See Figure 4-4)

NULL Meter Sensitivity. This test is a check of the amplifier gain and is performed as follows:

1. Connect two 120 ohm resistors, one across the active gage terminals and one across the compensating gage terminals of the two arm group.
2. Place Bridge Selector switch for two arm operation.
3. Set GAGE FACTOR to 2.0.
4. Place ADD TO READING switch on 30.
5. Rotate BALANCING Knob until the NULL meter indicates zero.
6. Record COUNTER reading.
7. Rotate the BALANCING control until the NULL meter pointer deflects to the third meter division either side of zero balance. Record the COUNTER reading.
8. The reading in Step 7 should not exceed the reading in Step 6 by more than 50 microinches per inch. If it does, the amplifier will require troubleshooting.

Perform Standard Calibration Procedure, 2.9. If meter does not react, then the amplifier is not working properly. Proceed to troubleshoot the amplifier as follows:

Remove the four screws that secure the amplifier to the instrument chassis, one at each corner of the printed circuit board. Lay the amplifier on a flat insulated surface. Disconnect only the input signal leads, terminals 1 and 2.

Connect an audio oscillator to the input terminals 1 and 2. Adjust the audio oscillator to provide an input voltage of approximately 20 micro-volts at the input.

Using the oscilloscope in the differential mode, check each transistor stage by connecting the oscilloscope leads to each stage, collector to collector. Once the amplifier is repaired, the adjustment below should be made:

Balance Adjustment

Short-circuit the input terminals 1 and 2 with a jumper lead. Connect a Simpson multimeter set to the 2.5 V DC scale, across the collectors of Q2 and Q3. Adjust R10 until the voltage that is measured on the meter is less than 0.05 V DC. Remove the jumper lead on the input terminals 1 and 2.

4.3.2.4 Measuring Circuit.

1. Measuring Board.

   The only malfunction that could occur on the Measuring Board would be a resistor shorted, opened or broken. The easiest method to trouble shoot the resistors is to turn off the power in the Indicator and perform a continuity test

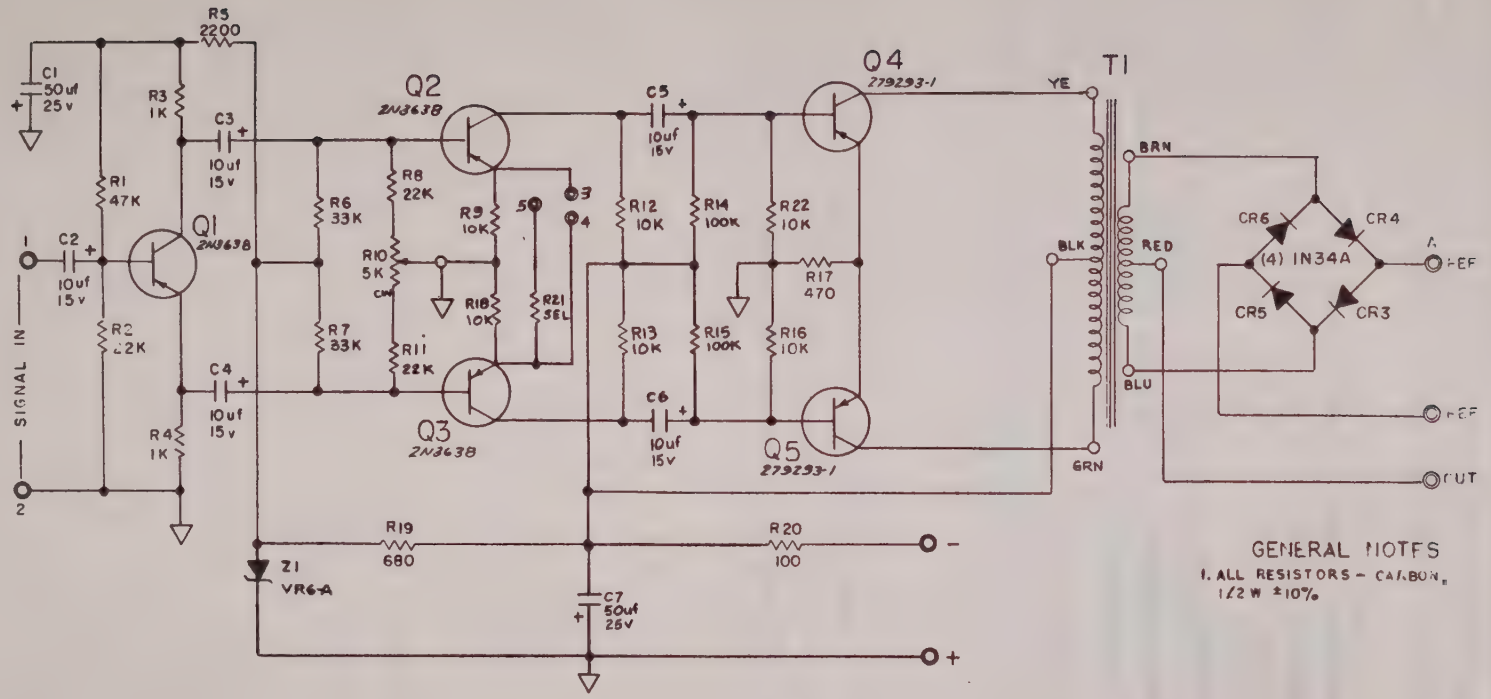



Fig. 4-4. Amplifier - Schematic Diagram

with a Simpton multimeter. Once the trouble is located and repaired, it is recommended that the Indicator be returned to BLH Electronics for recalibration, since these resistors are in the precision measuring circuit and different resistors may change the basic calibration.

If the trouble cannot be found easily, contact BLH Electronics for instructions to return the instrument.

2. ADD-TO-READING Switch.

If this switch or any of the resistors on this switch should become defective, it is recommended that the switch be replaced as a unit (switch with resistors mounted). Unsoldering and resoldering the resistors without proper heat sinks may cause a significant change in resistance.

It is recommended that the Indicator be sent to BLH Electronics for recalibration.

## 4.3 Parts List

The parts lists in this section are arranged in alpha numerical order according to component designation. As near as possible, standard terminology and designation letters are used. The lists provide the following information: Symbol Designation, General Description, BLH Part Number and Recommended Spare (RS) Parts quantity for complete maintenance during one year of isolated service.

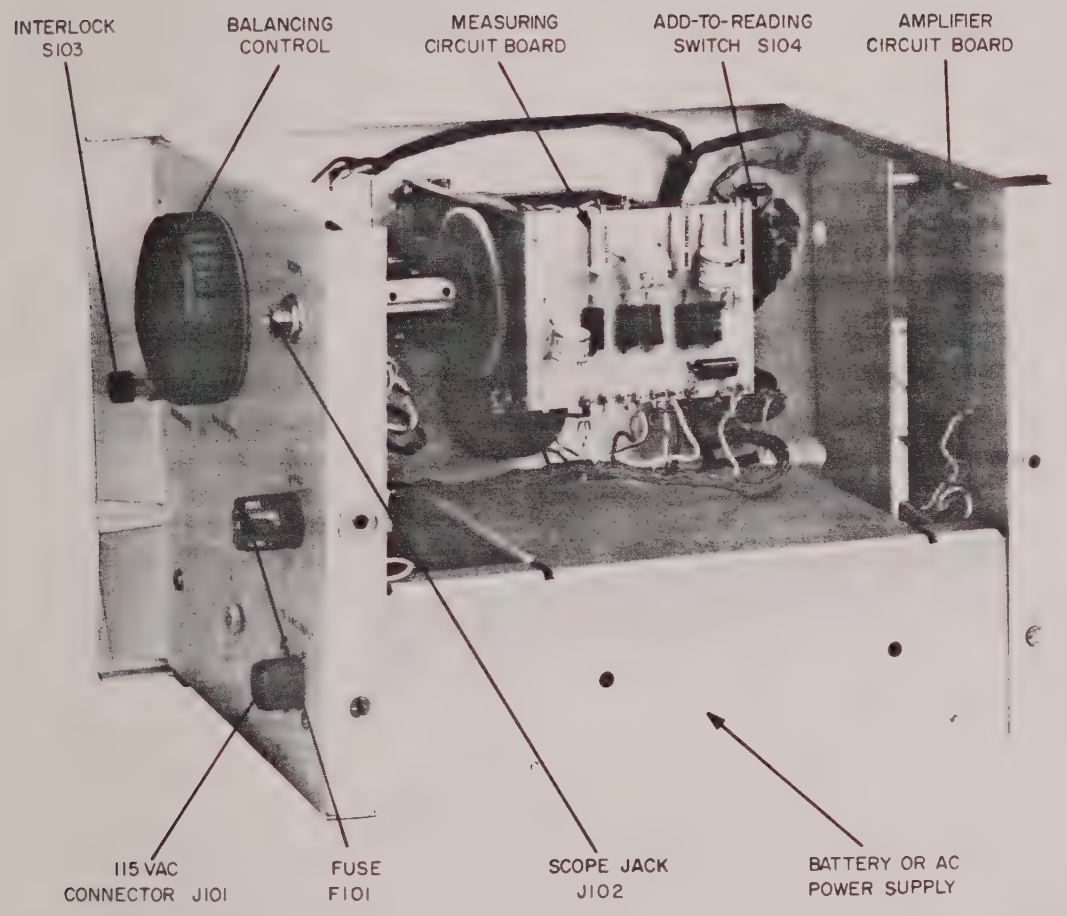



Figure 4-5. Model 120C Strain Indicator Major Components

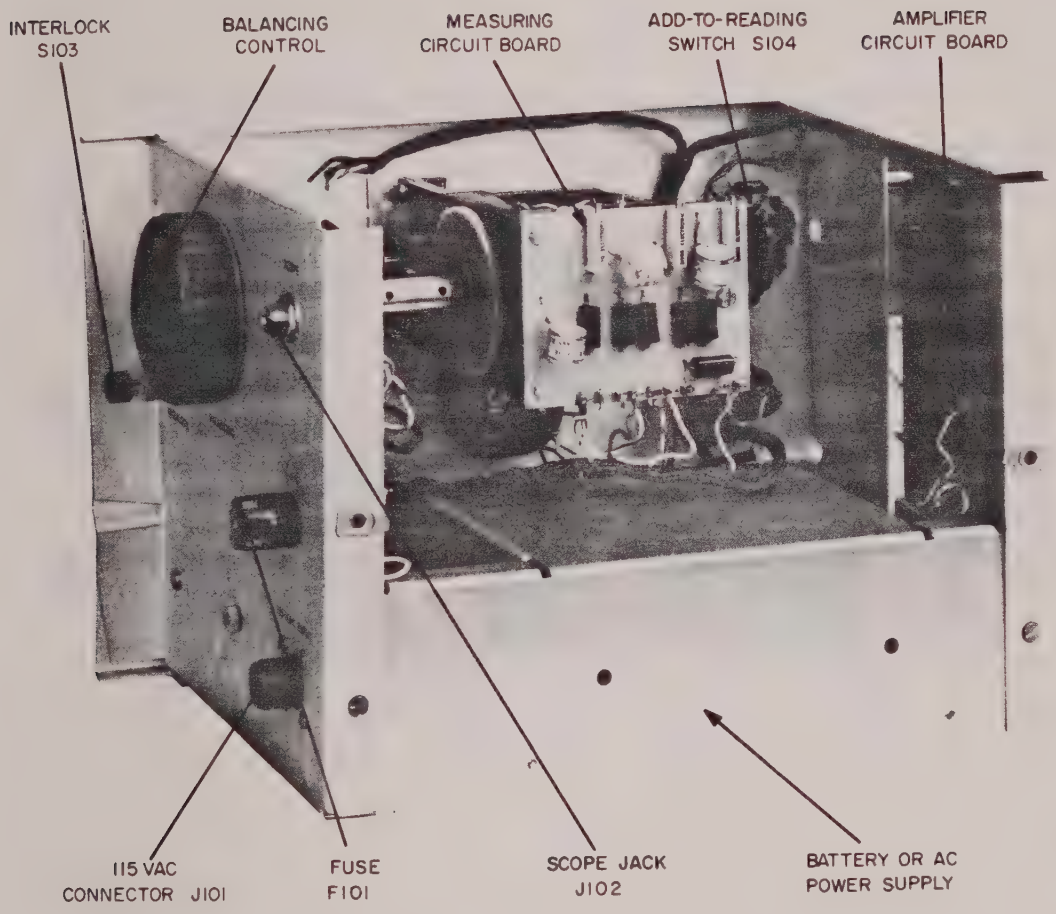



Figure 4-5. Model 120C Strain Indicator Major Components

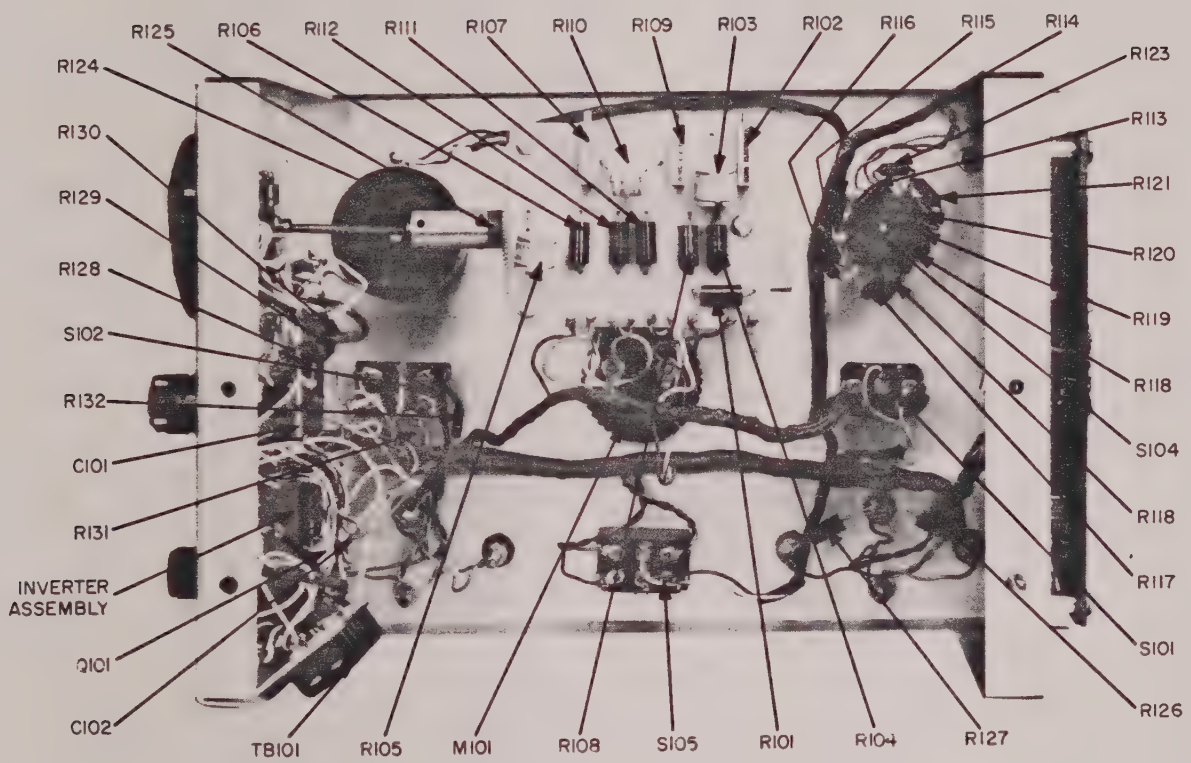



Figure 4-6. Front Panel, Rear View, Component Location

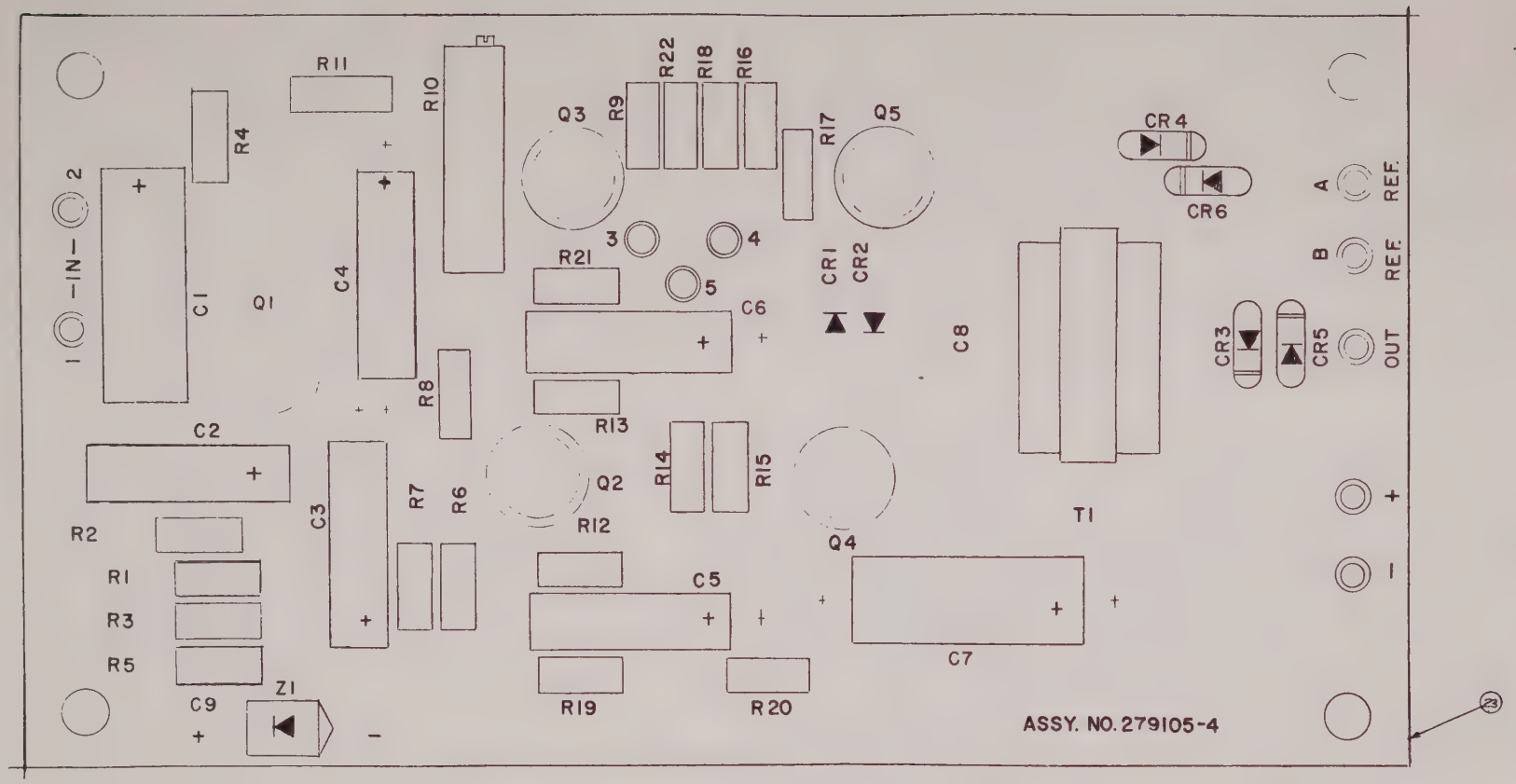



Figure 4-7. Amplifier Board Component Location

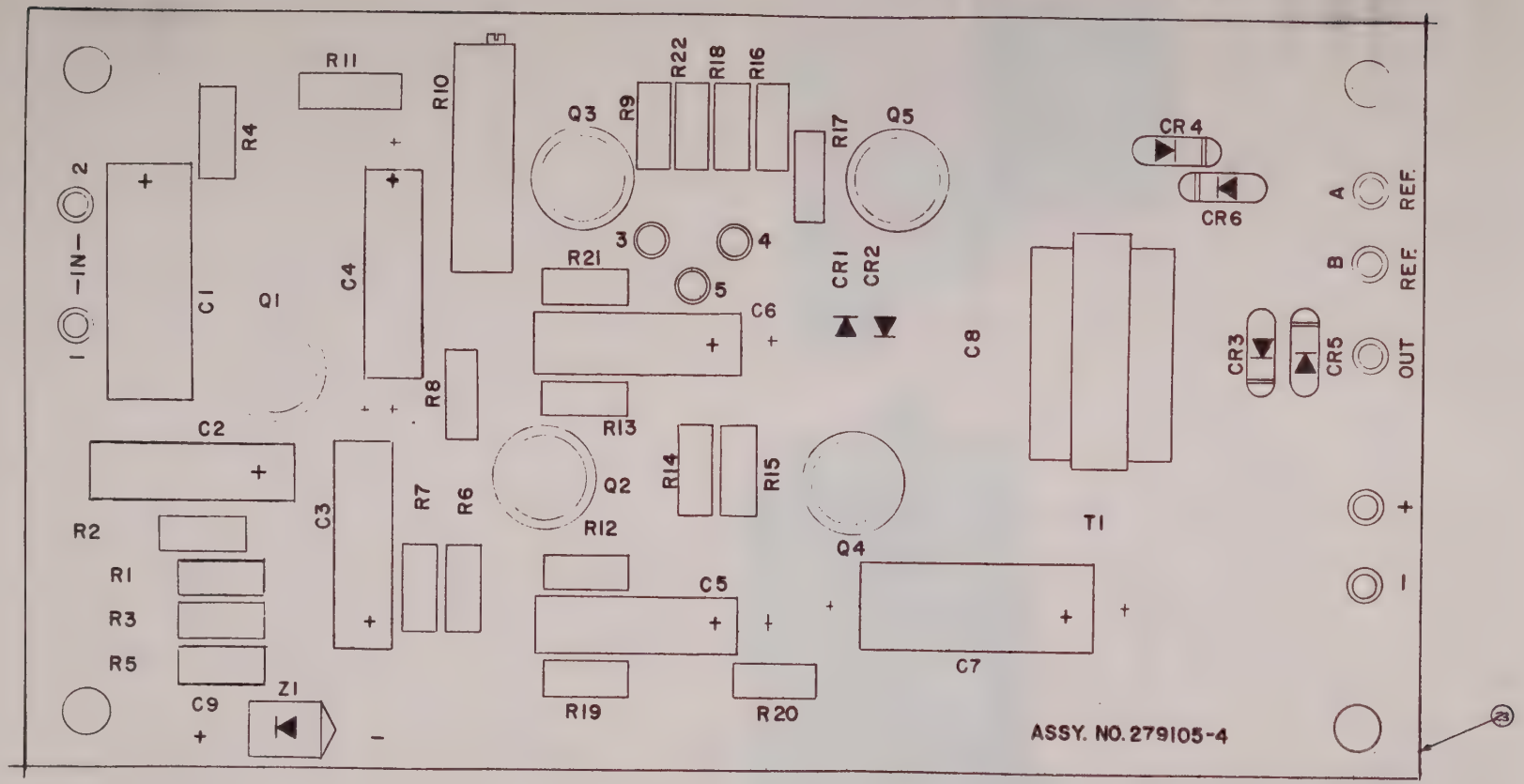



Figure 4-7. Amplifier Board Component Location

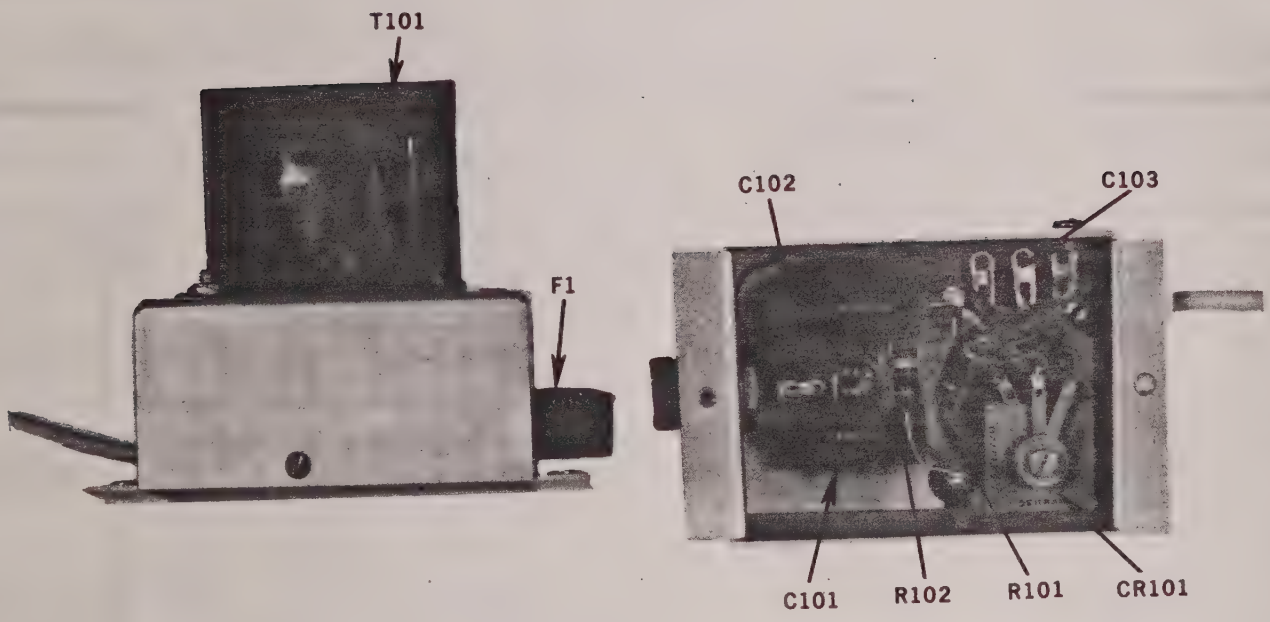



Figure 4-8. Power Supply, Component Location

| CIRCUIT SYMBOL | DESCRIPTION | BLH PART NO. | R.S. |
|---|---|---|---|
| BT101 | Battery, 6 volt | F4BP | 1 |
| BT102 | Same as BT101 | | 1 |
| C101 | Capacitor, .5μ F, (Dual) 400V | 132504-8 | |
| C102 | Capacitor, 1000μ F, 15V | 131195-8 | 1 |
| DS-R124 | Dial, Turn Counting, for R124 | 203301-1 | |
| DS-R125 | Knob for R125 | 203318-1 | 1 |
| DS-S104 | Knob for S104 | 124852-8 | 1 |
| E101 | Binding Post, Green | 135150-8 | 1 |
| E102 | Binding Post, Red | 135145-8 | 1 |
| E103 | Binding Post, White | 135146-8 | 1 |
| E104 | Binding Post, Black | 135149-8 | 1 |
| E105 | Same as E101 | | |
| E106 | Same as E102 | | |
| E107 | Same as E103 | | |
| E108 | Same as E104 | | |
| F101 | Fuse 1/8 amp | 128584-8 | 5 |
| J101 | Connector | 135099-8 | |
| J102 | Jack, Scope | 279102-1 | |
| M101 | Meter, Null | 400425-1 | 1 |
| Q101 | Transistor, 2N404 | 141719-8 | 1 |
| R101 | Resistor, WW, 50Ω, 1/4 watt, 1/2% | 134074-8 | |
| R102 | Potentiometer, Borg, 100Ω | 135645-8 | 1 |
| R103 | Resistor, WW, Select, 1/2% | Select | |
| R104 | Resistor, WW, 4.5K, 1/4 watt, 1/2% | 134075-8 | |
| R105 | Resistor, WW, 450Ω, 1/4 watt, 1/2% | 134082-8 | |
| R106 | Resistor, WW, 55Ω, 1/4 watt, 1/2% | 134073-8 | |
| R107 | Same as R102 | | |
| R108 | Resistor, WW, 800Ω, 1/4 watt, 1/2% | 134076-8 | |
| R109 | Same as R102 | | |
| R110 | Resistor, WW, 950Ω, 1/4 watt, 1/2% | 134083-8 | |
| R111 | Same as R108 | | |
| R112 | Same as R104 | | |
| R113 | Resistor, WW, 160Ω, 1/4 watt, .05% | 135510-8 | 2 |
| R114 | Same as R113 | | |
| R115 | Same as R113 | | |

| CIRCUIT SYMBOL | DESCRIPTION | BLH PART NO. | R.S. |
|---|---|---|---|
| R116 | Same as R113 | | |
| R117 | Same as R113 | | |
| R118 | Same as R113 | | |
| R119 | Same as R113 | | |
| R120 | Same as R113 | | |
| R121 | Same as R113 | | |
| R122 | Same as R113 | | |
| R123 | Same as R113 | | |
| R124 | Potentiometer, 100Ω | 204277-1 | 1 |
| R125 | Potentiometer, Slidewire, 200Ω | 101878-1 | 1 |
| R126 | Resistor, WW, 500Ω, 1/4 watt, .05% | 204863-1 | |
| R127 | Same as R126 | | |
| R128 | Resistor, Carbon, 1500Ω, 1/2 watt, 10% | 127220-8 | |
| R129 | Same as R128 | | |
| R130 | Resistor, Carbon, 1200Ω, 1/2 watt, 10% | 127219-8 | |
| R131 | Resistor, WW, 330K, 1/4 watt, 1% | 141923-8 | |
| R132 | Resistor, Carbon, 390K, 1/2 watt, 10% | 127213-8 | |
| S101 | Switch, Toggle | 133532-8 | |
| S102 | Switch, Toggle | 133531-8 | |
| S103 | Switch, PB | 205958-1 | 1 |
| S104 | Switch, Rotary | 274377-1 | 1 |
| S105 | Switch, Toggle | 133559-8 | |
| TB101 | Terminal Strip | 124865-8 | |
| XF101 | Fuse Holder | 131050-8 | |
| | Inverter Ass'y | 279050-2 | 1 |
| | Measuring Circuit Complete Ass'y | 279090-2 | |
| | Battery Cable | 202901-1 | |
| | Add to Read Switch, Complete Ass'y | 279125-2 | 1 |
| | Counter | 202785-1 | |
| | Index, Window | 202782-1 | 1 |

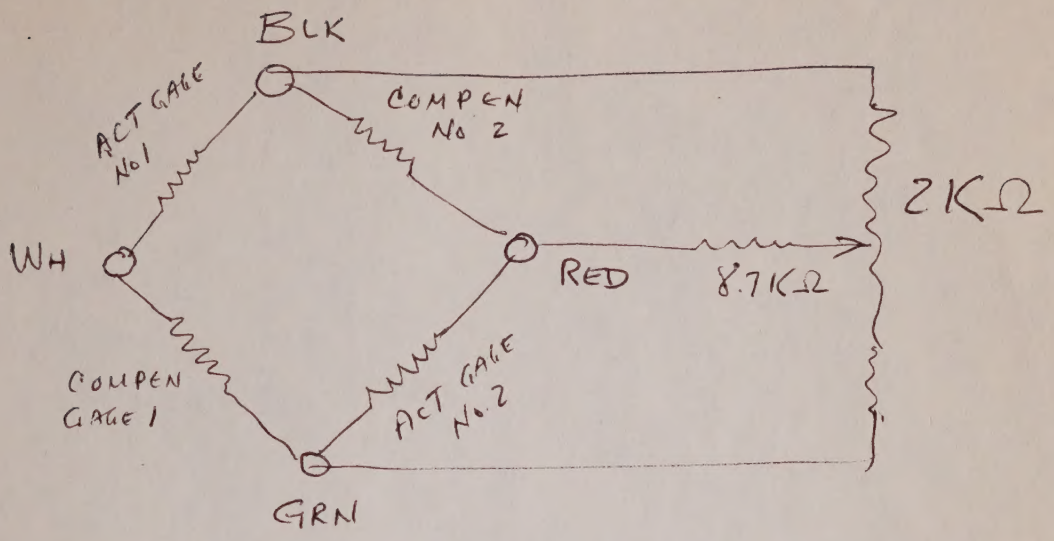
MODEL 120C AMPLIFIER

| CIRCUIT SYMBOL | DESCRIPTION | BLH PART NO. | R.S. |
|---|---|---|---|
| | Amplifier, Complete Ass'y | | |
| C1 | CAPACITOR, 50UF, 25V | 135381-8 | |
| C2 | CAPACITOR, 10UF, 15V | 135385-8 | 1 |
| C3 | Same as C2 | | |
| C4 | Same as C2 | | |
| C5 | Same as C2 | | |
| C6 | Same as C2 | | |
| C7 | Same as C1 | | |
| C8 | Not Applicable | | |
| CR1 | Not Applicable | | |
| CR2 | Not Applicable | | |
| CR3 | DIODE, IN34A | 135388-8 | 1 |
| CR4 | Same as CR3 | | |
| CR5 | Same as CR3 | | |
| CR6 | Same as CR3 | | |
| Q1 | TRANSISTOR, 2N3638 | 142099-8 | 1 |
| Q2 | Same as Q1 | | |
| Q3 | Same as Q1 | | |
| Q4 | TRANSISTOR, 2N3638, Q4 & Q5 Matched Pair | 279293-1 | 1 pr. |
| Q5 | TRANSISTOR, 2N3638, Q4 & Q5, Matched Pair | 279293-1 | |
| R1 | RESISTOR, Carbon, 47K, 1/2 Watt, 10% | 127238-8 | |
| R2 | RESISTOR, Carbon, 22K, 1/2 Watt, 10% | 127234-8 | |
| R3 | RESISTOR, Carbon, 1K, 1/2 Watt, 10% | 127218-8 | |
| R4 | Same as R3 | | |
| R5 | RESISTOR, Carbon, 2.2K, 1/2 Watt, 10% | 127222-8 | |
| R6 | RESISTOR, Carbon, 33K, 1/2 Watt, 10% | 127236-8 | |
| R7 | Same as R6 | | |
| R8 | RESISTOR, Carbon, 22K, 1/2 Watt, 10% | 127234-8 | |
| R9 | RESISTOR, Carbon, 10K, 1/2 Watt, 10% | 127230-8 | |
| R10 | POTENTIOMETER, 5K, 1/2 Watt, 10% | 135384-8 | 1 |
| R11 | Same as R8 | | |
| R12 | Same as R9 | | |
| R13 | Same as R9 | | |
| R14 | RESISTOR, Carbon, 100K, 1/2 Watt, 10% | 127242-8 | |
| R15 | Same as R15 | | |

| CIRCUIT SYMBOL | DESCRIPTION | BLH PART NO. | R.S. |
|---|---|---|---|
| R16 | Same as R9 | | |
| R17 | RESISTOR, Carbon, 470 ohm, 1/2 Watt, 10% | 127214-8 | |
| R18 | Same as R9 | | |
| R19 | RESISTOR, Carbon, 680 ohm, 1/2 Watt, 10% | 127216- 8 | |
| R20 | RESISTOR, Carbon, 100 ohm, 1/2 Watt, 10% | 127206-8 | |
| R21 | RESISTOR, SEL, 1/2 Watt, 10% | Select | |
| R22 | Same as R9 | | |
| T1 | Transformer | 401364-1 | 1 |
| Z1 | ZENER DIODE, UR6-A, ±10% | 135389-8 | 1 |

MODEL 120C-PS 12 VOLT POWER SUPPLY

| CIRCUIT SYMBOL | DESCRIPTION | BLH PART NO. | R.S. |
|---|---|---|---|
| | Power Supply, Complete Ass'y | 279136-2 | |
| C101 | CAPACITOR, 100μF, 25V | 135108-8 | 1 |
| C102 | Same as C101 | | 1 |
| C103 | CAPACITOR, .5μF, 200V | 128095-8 | |
| CR101 | RECTIFIER | 135100-8 | 1 |
| F101 | FUSE, 1/8 amp | 128841-8 | 5 |
| R101 | RESISTOR, 15Ω, 1/2 W, 5% | 132706-8 | |
| R102 | RESISTOR, 150Ω, 1/2W., 5% | 129833-8 | 1 |
| T101 | Transformer | | 1 |
| | AC Power Cord with Connectors | 102826-2 | 1 |




OXI SWITCH BOX (BLH)

THIS ARRANGEMENT FOR CANCELLATION OF BENDING -

TRUE STRAIN = $\frac{\text{READOUT}}{2}$